



3D view of the estimated recession at the MSL's heat shield front surface, 70 seconds after Mars entry during peak heating, from a simulation produced with the Porous-material Analysis Toolbox based on OpenFOAM (PAT0). This image shows the tiles' influence on heat shield recession, which is a potential promoter of transition from laminar to turbulent flow. A good estimate of the recession helps to correctly design the heat shield thickness and can significantly reduce the mass of an entry vehicle.
Jeremie B. E. Meurisse, Nagi N. Mansour, NASA/Ames

3D Heat Shield Simulations for Designing Future Space Vehicles

Aerospace engineers at NASA Ames are producing unique 3D simulations of the Mars Science Laboratory (MSL) heat shield to improve thermal protection materials for future space exploration missions. The team used the MSL's 4.5-meter diameter heat shield as a test case to successfully show that the Porous-material Analysis Toolbox based on OpenFOAM (PAT0) software can perform massively parallel simulations of material thermal response and recession rates—key design features to ensure an optimum trade-off between vehicle mass and safety. The differential recession between the tiles and the gap filler promotes the formation of a fence, which poses design challenges as it may promote transition to turbulence—an important factor in prediction and control of heat transfer in the extreme temperatures encountered during entry into planetary atmospheres.



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The MSL heat shield was assembled in 113 tiles with a uniform layer of 31.75 mm thickness. A silicone elastomer bonding agent is used to fill the gap between the tiles. This image shows the grid of 2 million cells used in massive 3D simulations of the heat shield material response.
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